SMARTSAT
COOPERATIVE RESEARCH CENTRE

SECTOR PRIORITIES

Agriculture and Natural Resources

This report should be cited as:
SmartSat 2021, Agriculture and Natural Resources Sector Priorities 2021, SmartSat CRC, Adelaide, Australia.

Acknowledgements and Preamble
The SmartSat is a collaborative consortium of industry and research organisations that are developing enhanced satellite connectivity, navigation and monitoring capability to propel Australia's space industry forward and generate transformative technologies to support sector needs. The technologies developed by SmartSat have the potential for application across a wide range of sectors.

As part of its planning, SmartSat had established three End User Boards to identify the challenges and needs of their sector and formed working groups to develop their respective Sector Priorities under the guidance of SmartSat's Industry and Deputy Industry Directors. Sector Priorities have been developed for: Agriculture and Natural Resources, Mining and Energy, Defence and National Security

These priorities will inform the SmartSat Research Program and help improve the sustainability and prosperity of critical sectors through harnessing transformative space industry technologies. Across each of the sectors, common problems have been identified which further highlighted the need for strong and robust cross-sector collaboration and the need for the space industry to leverage and pivot their technology and capability to service multiple sectors.

The priorities identified can be used by SmartSat partner organisations and the space community to help guide development of project proposals and identify priority areas for further research and development.

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Agriculture and Natural Resources Sector Priorities 2021

Purpose	To improve the sustainability & prosperity of the Agriculture and Natural Resources sector through harnessing transformative space industry technologies			
Summary	• The global space industry is growing at a rate of 9.5% compared to the global economy of 2.5% and it is expected to reach >$1 trillion in the next few years. • Transformative space technologies in the fields of connectivity, Earth Observation and positioning can help revolutionise the Agriculture and Natural Resources sector. • Optimising supply chains, managing risks and managing assets are key areas of the Agriculture and Natural Resources sector where space technologies can have significant impact.			
Sector Needs	**Need 1: Optimising Supply Chains** Enhancing supply chain profitability through better informed, accurate and timely decision making and reducing operational costs.	**Need 2: Managing Risks** Better identification, monitoring, mitigation and reduction of costs associated with sector risks including environmental, fiscal and WHS.	**Need 3: Managing Assets** Improved monitoring, management and utilisation of key infrastructure, plant and machinery, and labour.	**Need 4: Sustainability** Improve sustainability of the agricultural industries and our natural resources consistent with societal expectations while maintaining financial outcomes.
Priority Focus Areas	**Focus 1.1: Enabling digitisation and data-driven decisions** Connectivity capability that enables the adoption of digital technologies and supports more data-driven decision making. The ability to monitor and predict production outcomes with an improved ability to make tactical decisions. **Focus 1.2: Improved supply demand forecasting** Scalable tools and analytics that provide better supply/demand forecasting (domestically and globally) and support both pre and post farmgate decision making, e.g. purchase and deployment of inputs, end-product sales or purchasing strategies etc. **Focus 1.3: More informed production tactics** Developing production tactics to maximise productivity and optimise returns from management of pastures, cropping, horticulture and livestock. New approaches to monitoring and maintaining livestock condition from paddock to processing and managing livestock yield, grazing, and watering**.**	**Focus 2.1: Planning and responding to threats** Monitoring, mapping, and modelling tools to help businesses better understand, plan for, and respond to key threats including biosecurity, drought, fires and floods and other threats across the supply chain. **Focus 2.2: Reducing the cost of uncertainty** New tools and analytics that reduce the costs and improve options relating to financial instruments, e.g. mortgage, insurance, investment **Focus 2.3: Improving workplace safety** Farm owners and managers need to make sure that workers and other people on farms are not exposed to risks to their health and safety. Improved monitoring and handling of equipment and animals is important to reducing exposure to these risks.	**Focus 3.1: Managing Key infrastructure** Management and quality of key infrastructure is critical to the production and movement of agricultural products within and out of the country. Monitoring and control solutions that help track the status and support the operation of key physical infrastructure, e.g. roads, rail, ports, dams, irrigation etc. **Focus 3.2: Efficient use of plant, machinery and labour** Total management of machinery and labour is a significant cost component of agricultural production. There is an opportunity to optimise these costs through remote monitoring and analytics to improve utilisation. Transportation and logistical planning solutions that improve the utilisation efficiency of Total Plant, Machinery and Labour (TPML). **Focus 3.3: Supporting autonomous and remote operations** Autonomous and remote operations technologies that help reduce the costs and address shortfalls in labour and improve the timeliness and efficiency of key operations.	**Focus 4.1: Supporting natural assets** Monitoring and control solutions that support prosperity through sustainable practices, land use planning and the maintenance of high-quality natural assets e.g. waterways, soils and native flora and fauna etc. **Focus 4.2: Protecting animal welfare** Maintaining the welfare and health of livestock and native animals to meet standards consistent with sustainable production and societal expectations. **Focus 4.3: Addressing climate change threats** Programs to manage the impact of the agricultural industries on climate as well as their resilience with respect to the impact of climate change. Optimising carbon sequestration opportunities. **Focus 4.4: Drive environmental stewardship** Monitoring and assessing performance against the community's expectations with respect to sustainable agricultural businesses and management of natural resources.
Principles and Objectives	There is an overarching requirement to identify and define user needs and to enable adoption, reduce duplication and establish implementable solutions to needs and problems with potential for commercialisation sitting above five strategic pillars: 1. Delivery of RD&E projects that harness disruptive space industry technologies to help transform the Agriculture and Natural Resources sector 2. Building cohesive critical mass that is focused on key Agriculture and Natural Resources sector needs 3. Partner with the private sector to ensure path to market and adoption of SmartSat CRC outputs through to commercialisation 4. Communication that fosters adoption of new technologies and promotes collaboration 5. Assembling Data Analytics solutions that are FAIR (Findable, Accessible, Interoperable and Reuseable)			

1 Introduction

The SmartSat CRC (SmartSat) is a collaborative consortium of industry and research organisations that will develop enhanced satellite connectivity, navigation and monitoring capability to propel Australia's space industry forward and generate transformative technologies to support sector needs. It will catapult Australia to leadership in niche areas of intelligent satellite systems, advanced communications and Earth Observation driven data analytics.

The technologies developed by SmartSat have the potential for application across a wide range of sectors including Agriculture and Natural Resources. Transformative technologies in the area of Earth Observations from space, Global Navigational Satellite Systems (GNSS) and satellite enabled communications can address the gap between data and decisions for Agriculture and Natural Resources.

This document provides snapshot of key industry needs and research focus areas as well as a foundation for SmartSat to develop and implement projects and solutions based on the principles and objectives. The priority areas identified in this document were developed by the SmartSat CRC Agriculture and Natural Resources End User Advisory Board (EUAB).

This document will be used by SmartSat to guide the development of project-focused strategies and establish SmartSat priorities. The project strategies will take into consideration the impact, cross-sector collaboration, leverage of other initiative and programs, returns on investments, and returns and benefits to project partners and the industry as a whole.

This document may be used by SmartSat partner organisations to help guide development of project proposals and identify priority areas for further research and development.

2 Background

While the agricultural, fisheries and forestry sectors are highly diverse, they share common objectives. These include managing the productive capacity of the resource base (soils and water); managing yield from crops, horticulture fisheries or forests; maintaining livestock condition; maintaining product quality; managing biosecurity and maximising value to the consumer. This involves more than just efficiency of production on farm. It is also about managing the total supply chain, marketing the value of Australian agriculture to the final consumer, and protecting Australia's export markets.

It has been estimated[1] that the gains from digital agriculture could increase the gross value of Australian agricultural production, including forestry, fisheries, and aquaculture, by $20.3 billion. However, Australian agriculture is behind with respect to digitisation and this is affecting the ability of the industry to apply analytics and make data-driven decisions.

The research priorities and focus areas in this document were formulated by the Agriculture and Natural Resources EUAB based on the broad needs of the sector.

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[1] Precision to Decision project, sponsored by the Rural Research and Development Corporations (RDCs).

3 Strategic Principles and Objectives

The Agriculture and Natural Resources Priorities 2021 is framed by the following strategic principles and objectives:

- Delivery of RD&E projects that harness disruptive space industry technologies to help transform the Agriculture and Natural Resources sector

- Building cohesive critical mass that is focused on key Agriculture and Natural Resources sector needs

- Partner with the private sector to ensure path to market and adoption of SmartSat outputs through to commercialisation

- Communication that fosters adoption of new technologies and promotes collaboration, and

- Assembling Data Analytics solutions that are FAIR (Findable, Accessible, Interoperable and Reuseable).

4 Sector needs and research focus areas

Across the agriculture, food and agribusiness sectors are a range of different needs primarily focused on reducing costs, increasing efficiencies, or managing risk across the whole supply chain. Furthermore, sustainability is a key priority the Agriculture and Natural Resources sectors. For agriculture, sustainability encompasses managing water and soil resources sustainably, looking after animal welfare, maintaining biosecurity, food safety and addressing climate change threats.

The priority focus areas have been divided into four key categories outlined below.

4.1 Need 1: Optimising supply chains

There is a need to enhance supply chain returns through better informed, more accurate and timely decision making. Enabling digitisation and data driven decisions for producers across the whole supply chain, including consumers, will maximise returns from production and/or reduce operating costs.

The supply chain research focus area is concerned with developing user-friendly and implementable space-related technologies for increasing value along the total supply chain. This may involve a combination of new technologies linked into production and processing systems and the development of decision support tools and/or data analytics solutions.

It may also involve addressing the need for new tools to monitor and better inform production and supply tactics (crops, pasture, livestock etc) in real time and improve growers' ability to make decisions on production items such as stocking rates, fertiliser input or irrigation scheduling. Improvements in market forecasting (supply and demand) both domestically and globally will also support key supply chain decisions including purchase and deployment of key inputs.

Examples of potential research areas include:

- enterprise and paddock level monitoring of crop/biomass to assist producers to optimise production and meet product quality and plant health.

- controlled traffic farming, automation, robotics, drones using GNSS, to increase productivity from farm machinery for harvesting, sorting, yield monitoring and variable rate fertiliser applications.

- remote communications to link sensor and control technologies across farming enterprises and along the supply chain to improve management of production, monitor livestock, manage water, control pests and diseases and monitor the supply chain.

- integrating satellite data with GIS mapping of farms to better manage soil characteristics, biomass, animal condition, water points and property boundaries.

- use of multispectral and high-resolution radiometers to support monitoring crop and soil condition and moisture content.

- livestock monitoring, traceback and virtual fencing with augmented satellite positioning to improve the returns from livestock management and maintain animal health and welfare.

- improved and scalable supply chain monitoring (domestically and globally) to better forecast supply and demand, improve traceability, maintain quality and product differentiation.

- remote monitoring from producer to processor to optimise supply chain operations and generate cost savings.

- technologies to enable traceback to support biosecurity, quality management and marketing based on provenance.

- developing digital twins to capture and share data in secure formats, to support collaboration along the supply chain and increase returns to both producer and processor.

- applications of artificial intelligence techniques to provide fast and efficient analysis of production related data to reduce costs, manage quality, and deliver value to final consumers.

4.2 Need 2: Managing risk

The Risk Management focus area is concerned with increasing the industry's ability to identify, monitor and reduce costs across the sector and supply chains. This includes environmental, climate change, natural disaster, biosecurity and food safety, work health and safety risks, and product integrity along the supply chain. It also includes management of financial risk to improve options relating to financial instruments (insurance, mortgage, and investments) to reduce the direct financial cost of uncertainty.

To reduce this uncertainty and manage risk across the industry, the sector requires a better understanding of the data, access to new data, better tools and analytics for monitoring and forecasting, and support in planning an implementation of risk management and mitigation measures.

Examples of potential research focus include:

- objective measurement of the movement of products throughout the supply chain for integrity, quality, and traceability purposes and to minimise the potential for trade disputes.

- satellite imagery, satellite positioning and satellite communications to manage the impact of natural disasters and incursions of pests and diseases.

- use of satellite sensors for both terrestrial, ocean and air temperature monitoring to improve weather forecasting, optimise sowing schedules and improving water management.

- satellite imagery, communications, and satellite positioning technologies to better manage biosecurity, pests and diseases, and support traceback.

- satellite imagery and positioning technologies to better manage risks in the supply chain (e.g. tracking livestock/ live cattle exports/ boxed meat and traceability generally)

- use of space technologies, automation and monitoring to manage workplace health and safety and reduce associated risks of workplace injuries and exposure to hazardous environments.

4.3 Need 3: Asset management

Improved monitoring, management and efficient utilisation of key infrastructure, plant, machinery and labour is critical to the production and movement of agricultural products within and out of the country. This includes managing key infrastructure, and control systems to track the status of supply chain assets such as roads, rail, ports, dams, irrigation infrastructure and shipping will enable higher levels of support to operations. Therefore, the Asset Management research focus area is concerned with developing user-friendly and implementable space-related technologies for managing physical, natural, or human assets across the supply chain.

Significant savings in both time and cost can be achieved through increasing operational efficiency through monitoring and applying analytics to improve utilisation of plant, machinery and labour. For example, machinery plant and equipment are a significant component of costs: farmers in the grains sector have the equivalent of around 60% annual income, on average, tied up in machinery/plant capital[2]. Furthermore, agricultural labour can be difficult and costly to source in regional and remote areas. There is an opportunity to reduce these constraints while also improving the timeliness and efficiency of operations such as sowing, spraying, harvesting, mustering and transporting produce and livestock.

Examples of potential research focus include:

- satellite remote sensing, positioning and communications to optimise supply chain logistics.
- satellite imagery to monitor infrastructure critical to sustaining and capturing value along the supply chain.
- integrating space based remote sensing, in situ monitoring, sensors and control systems to enable autonomous vehicles, robotics to improve productivity on farm and along the supply chain.
- governance, licensing, and protocols for sharing of data to support use of advisory services, supply chain management and analytics to improve returns along the whole supply chain.

4.4 Need 4: Sustainability

One of the most significant challenges facing the sector is ensuring sustainability of the agricultural industries and of Australia's natural resources. The Sustainability research focus area addresses development of sustainable systems, enhancing the sustainability of the supply chain and supporting the sustainability of the agricultural and NRM sector in line with social expectations while maintaining financial outcomes.

This has many dimensions, including supporting the prosperity of agricultural industries through sustainable practices such as land use planning and maintenance of high-quality natural resources such as water management, water usage, evaporation, run-off, and ground water monitoring. It also includes protecting animal welfare through remote monitoring of the health and welfare of livestock and native animals both on farm and along the supply chain. The use of remote monitoring and benchmarking mechanisms is also required to ensure that the agricultural industries are equipped to maintain Social Licence to Operate.

Furthermore, climate is the biggest individual driver of production variability in agriculture, and accounts for one-third to two-thirds of annual global crop yield variability. It is vital to manage the consequences of climate change and support mitigation through activities like optimising carbon sequestration.

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[2] https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2015/03/machinery-purchases

Example project areas include:

- use of satellite imagery and sensors to map vegetation and biomass for management of production and assessment of production for marketing purposes.

- satellite communications and sensors to support objective measurement of animal health and monitor animal welfare along the supply chain.

- satellite-based remote sensing for water resource monitoring and management of water use on farms and in water basins.

- satellite imagery and terrestrial sensors and positioning to develop pre-emptive programs to reduce incursions of pests and diseases.

- remote sensing, positioning, and communications to monitor supply chains to ensure maintenance of food standards and quality.

- satellite imagery to monitor biomass to optimise and monitor carbon sequestration and carbon emissions.

5 Adoption of Technology and National Collaboration

In the Agriculture and Natural Resources sector there is a need to bridge the gap between the vast and transformative potential available from space-based technologies and the practical needs of producers and managers in the sector. This document provides a summary of the sector priorities and focus areas, but it is also important to understand the end-user needs, including barriers to adoption of technology. Furthermore, a national collaborative approach is required to leverage R&D, capabilities and investment across the sector.

5.1 Adoption of technology

Understanding end-user needs and the factors that influence adoption of technology is critical in developing practical and implementable solutions. Research activities are required that focus on the social sciences (psychology, economics, marketing, social licence, etc) as well as regulatory and multi-disciplinary technical investigation (law, engineering, design, HMI, data, etc). Specifically, these preliminary research efforts should aim to understand:

- enablers and barriers to technology adoption including skills, capability and capacity, socio-demographics, business models, local infrastructure, costs and returns on investments

- drivers and barriers of social acceptance of technology (communities and customers)

- modes of effective education, communication, or demonstration systems to encourage adoption and acceptance

- existing technologies that fulfil needs with minimal investment from within and external to the sector

- the legislative, regulatory, and ethical dimensions of existing and new space technologies and related issues such as data sharing and privacy

- the drivers and barriers to commercialisation including collaboration, costs structures and the economic value of data and technology

- issues relating to interoperability and user-friendly access and design.

5.2 Leverage and collaboration

There are many research institutions, industry bodies and government programs in the Agriculture and Natural Resources sector. This includes research funded by the Rural Research and Development Corporations (RDCs), the CSIRO including Data 61, universities and programs supported by the Commonwealth and state/territory governments. There are also research and development activities underway in other sectors, notably in Mining and Energy, Defence and National Security, Transport and Logistics, Emergency Services, Communications and Earth Observations that present cross-sector opportunities for leverage and collaboration.

Greater clarity on national priorities and cross sectoral opportunities will be important to maximising the value of research funding nationally. This will be a key driver when formulating research projects for Agriculture and Natural Resources sector, to avoid duplication, take advantage of relevant developments in other sectors and encourage collaboration.

A brief overview of relevant space systems and services is provided at Appendix A and an overview of RDC focus areas is provided at Appendix B.

6 Concluding Remarks

The Agriculture and Natural Resources Sector Priorities were developed with the aim of identifying priority industry needs and associated research areas that can be targeted by the SmartSat space community. Similar activities within the Mining and Energy EUAB and Defence and National Security EUAB have resulted in similar sector priority documents being developed. Across each of these sectors, common problems have been identified which further highlighted the need for strong and robust cross-sector collaboration and the need for the space industry to leverage and pivot their technology and capability to service multiple sectors.

The priority areas identified here and in other sectors lay the foundation for developing project-focused plans that further detail the establishment projects that provide maximum impact and benefit within the sector and enhance cross-sector collaboration to leverage capability and investment and avoid duplication. Further research may also be required to gain a deeper understanding of the end-user needs including barriers and drivers to technology adoption.

SmartSat will continue to invest in and establish early concept research projects while the Sector Plans are being developed. As such, the priorities identified here should also be used by SmartSat partner organisations to help guide development of project proposals and identify priority areas for further research and development (R&D).

Appendix A - Space Based Services Relevant to Agriculture and Natural Resources

This Appendix outlines space-based services that support applications in the agricultural, fisheries and forestry sector and that have the potential to substantially increase net returns across supply chains and sustainability of the sectors of the natural environment

There are three space-based services that are relevant to Agriculture and Natural Resources, Earth Observations from space, global satellite navigation systems and communications. Each of these services provides data that when integrated with other technologies such as geographic information systems (GIS), sensors and control systems, data exchanges and analytics, are increasingly applied in Agriculture and Natural Resources to improve the profitability and sustainability of the sector.

A-1. Earth Observations from Space (EOS)

EOS involves utilisation of imagery, microwave, infrared, synthetic aperture radar, scatterometers altimeters and radiometers to capture data that can be adapted to assessing soil and moisture content, vegetation cover and conditions and air temperature. The technologies can also be used for terrestrial and ocean monitoring important used in weather forecasting. General details are included in Table 1.

Table 1 Satellite sensors and applications

Sensors	Details	Applications
Optical sensors	Low to medium resolution (10-30 metres) High resolution (2.5o10 Very high resolution (50 cm-2.5 metres metres) Various spectral ranges capture different features. Multispectral, hyper spectral and infrared capabilities.	Environmental data, land use and land use change vegetation and land cover Monitoring vegetation, fires, water Moisture in vegetation using infrared bands
Synthetic aperture radar	Microwave sensor capable of imaging the earth regardless of time of day, cloud haze or smoke	Measuring canopy cover, vegetation
Radiometers	Measure electromagnetic radiation	Monitoring temperature, of soil, vegetation, water, plant canopy, water vapor and salinity
Scatterometers	Measures the return of a beam of light or radar waves scattered by diffusion in a medium such as air	Used for deriving wind direction and speed from the roughness of the sea.
Gravity	Experimental work with Gravity Recovery and Climate Experiment (GRACE)	Changes in gravity detected from satellite have been used to map ground water

A-2. Global Satellite Navigation Systems (GNSS)

GNSS has become a foundation positioning technology over the past 30 years following the introduction of the US Global Satellite Service in the 1980s. There are currently six GNSS systems operating. The most utilised in Australia is the US Global Positioning Service (GPS). However basic GNSS is subject to errors of up 100 metres on some occasions and it provides no indication of integrity. GNSS signals can be augmented using space-based or ground-based correction signals to improve the accuracy and integrity of the signal. The Australian Government is investing in a Space Based Augmentation System (SBAS) that will provide sub-metre accuracy over all of Australia and New Zealand. In some areas the accuracy can be up to a decimetre. SBAS will provide valuable accuracy to agricultural and natural resources management applications.

A-3. Satellite-based communications systems

Communications systems are a critical infrastructure if the benefits of space-based data and related systems are to be realised. Surveys of the agriculture sector undertaken in 2017 showed that poor communications services in rural areas were a concern to many producers.

Inadequate bandwidth for internet connections and poor mobile coverage in regional and remote areas are a key barrier to adoption of some of the newer applications that are being developed for the agricultural sector.

NBN Co. provides internet services to remote areas through its Sky Muster satellite service. However, the communications across farms remain an area of concern. Some companies are developing space-based technologies provide communications that could address the needs of agricultural producers.

However, at the present time, there remain concerns over lack of coverage for internet of adequate bandwidth and mobile coverage in remote areas.

Appendix B - Sector Imperatives and RDC Focus Areas

There is abundant potential for NRM to make use of space and digital technologies. In Australia the NRM system is managed on a regional basis with input from local, state and federal governments.

NRM Regions Australia is the national representative group of Australia's 54 regional NRM bodies that cover the continent. Natural Resource Management (NRM) is the responsible use of our land, water, soil, plants, and animals for current and future generations. NRM bodies work collaboratively from a local to national scale to address issues with a whole-of-landscape perspective. This helps to maintain a healthy and productive country that supports viable communities and industries.

In recent years, digital technologies have allowed NRM stakeholders to develop data collection tools and methodologies that provide critical information more frequently, reliably and transparently. These technologies assist with mapping and understanding of remote locations and changes to environments over time. They also assist with monitoring and compliance. State governments are increasingly reliant on satellite imagery for managing native vegetation.

Areas for digital innovation include forest management, wildlife conservation (counter-poaching and species preservation) and sustainable fishing practices were highlighted in a recent international report[3] which also notes barriers and opportunities for space technology in the sector:

- Drones are widely used in marine and forest sectors and when combined with mobile data collection tools, they are highly effective at mapping and documenting land rights.
- Interest in connected devices is increasing, but the cost of devices remains a key barrier.
- New business models and collaborations are building IoT ecosystems and generating cost efficiencies.
- There are increasing opportunities to use space technologies to engage with local communities and stakeholders for the purposes of increasing awareness, understanding and improving education in the NRM area.

The following section presents a summary of 12 RDC priorities and focus areas in relation to space and digital technologies within their respective commodity groups. Some of the specific RDC technological investment and research priorities are presented in the margin.

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[3] GSMA, 2020, Digital Dividends in Natural Resource Management. Available at: https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2020/05/GSMA_Digital-Dividends-Report-2020_68pg_WEBv3.pdf

B-1. AgriFutures Australia

Consistent with their vison of improving the prosperity of Australia's rural industries, AgriFutures' latest Strategic R&D Plan (2017-22)[4] includes four focus areas which address 'people and leadership', 'challenges and opportunities', 'profitability' and 'emerging industries'. Over the next five years, AgriFuture's Chair has made a commitment to deliver knowledge and technology focus areas to ensure growth across profitability, sustainability, and emerging industry investment.

Specific to AgriFuture's second focus area of addressing challenges and opportunities, the goal is to identify research and innovative opportunities that address industry issues and deliver collective benefits. More specifically, investment focus areas are on climate change, natural resource management, safety and welfare. Technological priorities under this focus area prioritise genetics, sensory systems, IoT, device connectivity and remote sensing, automation and traceability. To realise the benefits of these technologies, AgriFutures highlight the need for greater collaboration on common issues across sectors, RDCs and government.

AgriFutures also address some of the global megatrends that have the highest potential to impact industry and have been considered in the development of their Plan. These include advances in digital technology, genetics, synthetics and other transformative technologies. The challenge of addressing public perceptions about new technology and the risk of regulatory frameworks bottlenecking adoption is also highlighted.

Following the release of their Strategic R&D Plan in 2017, AgriFutures explore the emergence of AgTech which aims to solve challenges along the supply chain in their report *Accelerating the development of AgTech solutions worth adopting*[5]. AgriFutures highlight the emergence of AgTech and identify new technologies such as satellites, sensors, data analytics, AI, gene editing and microbiology as being increasingly accessible and affordable, which is driving new investment. AgriFutures support the emerging AgTech ecosystem through their focus area evokeAG and in their research publications.

B-2. Australian Pork Limited

Australian Pork Limited (APL) highlight the importance of technology and the use of improved communications and knowledge transfer initiatives in their Strategic Plan6. Their Plan contains five strategic themes, two of which are to build a shared industry vision (including technology adoption) and to lead community social licence (including climate friendly farming, biosecurity leadership and transparency). Through its consultation with industry, APL collated nine key priorities, including knowledge management, volatility reduction, innovation in health and convenience and cost efficiencies.

In the context of building a shared vision for the industry, APL's Strategic Plan has a specific focus on providing beneficial, easy-to-use and implementable technology for industry. Some examples explored later in the Plan (and some technology impacting the

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[4] AgriFutures (2017), *Strategic R&D Plan 2017-22*
[5] AgriFutures (2018), *Accelerating the development of agtech solutions worth adopting*
[6] Australian Pork Limited (2020), *Strategic Plan 2020-25*

operating environment) include productivity improvements in genetics, climate change adaptation and digital marketing.

In line with the National and Rural Research and Development Priorities, APL restate their commitment to ensure the industry remains focused on improving animal welfare, biosecurity, soil, water and natural resource management, traceability, product quality and safety, animal health and pig management practices.

APL's technological research priorities are further evident in their 2018-19 Annual Report which has a strategic objective to 'improve capability' and an associated focus area 'applied learning' which specifies technology adoption and awareness as two key KPIs[7]. The proposed outcomes are to improve adoption of solutions across the supply chain and to increase awareness of RD&E initiatives, such as traceability focus areas (e.g. Physi-TraceTM and APIQ✓®), scanning technology (e.g. PorkScan Plus, 3D scanning), biosecurity technologies and surveillance, real-time technology to improve pig management. Additionally, APL's cross-sectoral initiatives included advanced measurement technology, virtual herding and high-throughput technologies.

B-3.   Australian Wool Innovation

Specific priorities

Augmented reality
Data mapping
Traceability
Sensors and alerts
Smart tags
Virtual reality
Virtual fencing/ herding
Machine learning/ AI
Wearable technology
Autonomous shearing

Australian Wool Innovation's (AWI) primary role is to invest in research, development and marketing to enhance the industry's sustainability and profitability of its levy payers. In recent times, the focus of AWI has shifted towards addressing climate pressures and changing demand from international markets[8]. The 2019 AWI Strategic Plan includes 13 strategies concerning animal health, AgTech, technology uptake, processing innovation, education and extension, supply chain initiatives and fibre science, among others. The AWI CEO specifically highlights the importance of promoting technologies such as augmented reality, data mapping, traceability (e.g. WoolQ platform) and improving the flow of information along the supply chain.

The AWI Strategic Plan provides more detail about their technological priorities to 2022. Within the 'healthy productive sheep' strategy, AWI aim to implement genetic tools and AgTech such as sensors, machine learning (e.g. AWI Smart Tag), robotics (e.g. robotic shearing system), as well as to deliver digital literacy within industry. Within the 'processing innovation' strategy, AWI target to deliver trials of wearable technology and there is a specific focus area relating to improving the uptake of technology, training and education (i.e. Woolmark Learning Centre digital platform).

During AWI's consultation with industry, the theme of 'digital development' emerged and the need for additional investment in AgTech to entice the next generation and reduce focus area overheads was a common message. AWI has incorporated this feedback by committing to the use of mechatronics (i.e. proof of concept for robotic shearing), automated data collection and AI in their Plan's targets.

AWI also discuss the current operating environment impacting the industry and concerns the 'digital landscape' and how technology has changed their processes. Looking towards the future, AWI note their focus on the emergence of AgTech (e.g. blockchain) and Fashion-Tech (e.g. innovative production, processing and connectivity), data transformation (e.g. data mapping and predictive analytics) and emerging retail

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[7] Australian Pork Limited (2019), *Annual Report 2018-19*
[8] Australian Wool Innovation (2019), *Strategic Plan 2019-22*

technology (e.g. Near Field Communication, Augmented Reality, garment sensory technology) and smart wardrobes.

The 2018-19 AWI Annual Report[9] reiterates some of the Plan's focus areas including "some very exciting results" in relation to gene editing technology, smart tags and artificial intelligence. AWI also highlight the potential of innovation in nanotechnology, camera and trap technology, genomic parentage and virtual fencing. AWI also highlight some of their projects such as semi-autonomous shearing (robotics) and digital farm management tools (e.g. LTEM app).

B-4. Cotton Australia & Cotton Research Development Corporation

Specific priorities

Digital education
Traceability
Biotechnology
Digital agriculture
Big data & AI
Robotics
3D printing
Synthetic biology
Genetic science

As the peak body for Australia's cotton growers, Cotton Australia promote three key goals in their 2018-23 Strategic Plan[10] which are to deliver a viable (sustainability and fairness), an advanced (technology, systems, innovation and skills) and a valued industry (services, community and trade). Cotton Australia define their role as protecting existing technology and to foster innovation for the future ('viability'), assist growers to be profitable and innovate ('advanced') and to assist in the delivery of essential, valued services using modern processes and systems ('valued').

Cotton Australia's strategic framework addresses how it aims to meet these three broad goals and includes activities such as driving participation in myBMP (digital assurance and education mechanism), enhancing access to science, innovation and technology, preparing growers for digital agriculture adoption and to improve quality, sustainability and traceability. To measure its own success in facilitating the uptake of this technology, Cotton Australia will assess itself against growers' preparedness to use integrated management systems (i.e. biotechnology), new technology such as digital agriculture, big data and biotechnology innovations.

The Cotton RDC (CRDC) Strategic Plan[11] promotes similar focus areas as Cotton Australia, with goals including to increase productivity, improve sustainability and competitiveness, build adaptive capacity, strengthen partnerships and adoption (i.e. innovation and commercialisation) and to drive RD&E impact. Some specific focus areas for CRDC concerning technology include the optimisation of farming systems using transformative technology, improving measurement throughout the value chain, science, and innovation capability.

To combat the future threats to its industry and its operating environment, CRDC identify 10 drivers which are having the highest impact on the industry. In relation to technology, some include technology advances (e.g. artificial intelligence, robotics, 3D printing, blockchain systems, genetic science, synthetic biology and data driven technology) and the increasing awareness of markets and consumers which makes traceability technology a critical consideration for producers.

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[9] Australian Wool Innovation (2019), *Annual Report 2018-19*
[10] Cotton Australia (2018), *Strategic Plan 2018-23*
[11] Cotton Research Development Corporation, (2018), Strategic RD&E Plan 2018-23

B-5.   Dairy Australia

Since 2017, Dairy Australia (DA) have expressed an interest in prioritising busines profitability competition, growing skills and capability, and protecting and promoting the industry[12]. In relation to their 'profitable' priority, DA highlight their focus on animal health, advanced management technologies, manufacturing innovation, genetic improvements of animals and feedbases (e.g. DairyBio and DataGene) and digital communications in their direction. DA further explain their role in supporting technical advances in digital technology (i.e. data and connectivity), automation and renewable energy (i.e. solar) as well as the opportunities that exist in irrigation technology, feeding systems, resource use efficiency and monitoring.

DA's 2021-2025 strategy is yet to be finalised, however, their regional team Subtropical Dairy released its Strategic Plan[13] for the 2017-2022 period. This Plan has a mission to drive and facilitate collaboration, research, education, technology and empowerment within the dairy industry. Some of Subtropical Dairy's strategic areas discuss the farm operating environment, feed and nutrition, animal performance and RD&E. Subtropical Dairy also highlight some specific challenges and opportunities to the industry such as the cost of climate variability, technology to improve forage quality and genetics, reproductive technology and genetics and genomics and communication technology.

DA's 2018-19 Annual Report[14] further explores some of their priorities and has a clear focus on climate change, water, animal welfare and gene technologies. DA's strategic focus areas include AgTech and innovation, feedbase and nutrition, genetics and fertility. DA highlight their relevance to the Rural R&D Priorities with a focus on innovation in genetics, precision agriculture, robotics, digitisation and big data. Some specific projects include Improving Reproductive Performance, Dairy Bioscience, Animal Nutrition and Feed Systems, AgTech and Innovation, On Farm Nutrient Management, Climate Change Adaptation and Water Use Efficiency.

B-6.   Fisheries Research and Development Corporation

The Fisheries Research and Development Corporation's (FRDC) 2020-25 Strategic Plan[15] (draft) provides an insight into their proposed technological priorities for the next five years. As the leading organisation for facilitating innovation in the industry, FRDC have five 'enabling strategies' and some include driving digitisation and advanced analytics, strengthening transformational change and promoting innovation in the industry.

More specifically, the 'driving digitisation and analytics' strategy encapsulates the availability of real time data, remote monitoring (e.g. on stock health, feed efficiency, disease incidence), automation, satellite imagery, drones, sensors, machine learning, monitoring and surveillance tools. FRDC state that they will explore opportunities to invest in, manage and promote the adoption of this R&D. In relation to 'building capability and

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[12] Dairy Australia (2017), Strategic Plan 2016/17 to 2018/19
[13] Subtropical Dairy focus Programme Ltd (2017), Strategic Plan 2017-2022.
[14] Dairy Australia (2019), Annual Report 2018-19
[15] Fisheries Research Development Corporation (2020), Strategic Plan: imagining the future of fishing and aquaculture today

capacity', FRDC plan to focus their investment on digital and technological proficiency, communication for transparency and supply chain integrity, biosecurity scanning and environmental stewardship technology that enhances stocks and ecosystems.

The FRDC 2018-19 Annual Report[16] provides additional insight into some of the focus areas for the FRDC over the coming years including a focus on developing risk assessment tools, implementing new approaches to innovation, deliver innovation acceleration focus areas, investing in wild fishery capture methods and species growing R&D projects.

B-7.   Forest & Wood Products Australia Limited

Forest and Wood Products Australia (FWPA) have five key strategic priorities including the promotion of wood products, alignment of products and the market, value chain optimisation, resource availability and decision making[17]. Within these priorities, FWPA aim to provide innovative teaching resources ('promotion'), support wood building technologies ('alignment'), adopt new technology and data analysis techniques such as big data ('optimisation'), support the use of genetics ('risk reduction') and develop systems to aggregate data and management indicators ('decision making'). FWPA also discuss the potential for new technology such as virtual reality and renewables (e.g. The Ultimate RenewableTM).

As expected, FWPA's Annual Operating Plan[18] aligns will with their Plan and presents similar technological priorities and opportunities such as data collection devices, data analytics and 'big data', wood building technologies, automation and virtual reality.

FWPA's 2018-19 Annual Report[19] provides some more specific examples in how the RDC uses and may make use of technology in the near future. FWPA discuss their growing use of virtual reality (e.g. ForestLearning, ForestVR), communication initiatives (e.g. WoodSolutions) and their growing sustainability and renewable focus (e.g. The Ultimate Renewable and Naturally BetterTM). Additionally, FWPA have recently supported and funded the rapid evolution of remote-sensing technologies, virtual reality applications and plant pest surveillance focus areas (iMapPESTS) in partnership with Hort Innovation. FWPA also discuss their involvement in a world first project focusing on genetics technology and breeding to enhance tree growth rates.

B-8.   Grains Research and Development Corporation

Grains Research and Development Corporation's (GRDC) 2018-23 RD&E Plan[20] outlines their investment priorities for the next few years and provides insight into potential profitability enhancers, the industry's future challenges and the importance (and Australia's reliance) on innovation and new technology to remain competitive. The Plan also highlights some global drivers of change including big data, AI, modelling, forecasting, automation, machine learning and blockchain.

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[16] Fisheries Research Development Corporation (2019), Annual Report 2018-19
[17] Forest and Wood Product Australia (2020), Strategic Plan 2020-25
[18] Forest and Wood Product Australia (2020), Annual Operating Plan 2020-21
[19] Forest and Wood Products Australia (2019), Annual Report 2018/19
[20] Grains Research Development Corporation (2018), Research, Development and Extension Plan, 2018-23

GRDC have four core frameworks that underpin all RD&E investments including data management and analytics, biosecurity, grower communication and capacity and skills. The 'data management and analytics' framework specifies GRDC's commitment to building a digital agri-portfolio comprising of tools such as farm management data, soil mapping, high-resolution imagery, climate and weather data (in combination with artificial intelligence), real time connected technologies and remote sensing. The 'biosecurity' framework also highlights the importance of surveillance and pre-emptive controls.

At a more granular level, GRDC's objective to 'maintain and improve price' identifies investment targets of food safety and traceability, sustainability and innovative processing technology. GRDC's objective to 'optimise input costs' includes the investment targets of sensor/monitoring technology, fertiliser efficiency technology and reducing labour costs using automation and robotics. GRDC also highlight their targets at the 'post farm gate' stage, including transport and handling automation.

B-9.   Hort Innovation Australia Limited

Specific priorities

Communication and extension
Biosecurity surveillance
Crop monitoring
Precision ag.

Hort Innovation's 2019-2023 Strategic Plan introduces three strategic pillars which are to drive knowledge and innovation (focusing on communication and extension), deliver high value R&D, marketing and trade investment and enabling activities that drive strategy[21]. The RDC's Innovation Chair specifically highlights climate variability, labour, natural resources, market fluctuations, trade barriers and pests as core challenges to the horticultural industry and the RDC's consultation with industry identified a shared vision to adopt more technology such as robotics, sprayers, probes and renewable power.

In relation to the RDC's 'drive knowledge and innovation' pillar, key technological initiatives include optimising investments in communication and extension and building digital platforms to streamline content. Under the second pillar, which focuses on the delivery of high value R&D, the key technological initiative is to invest in commercialisation capability and drive innovation.

Hort Innovation also discuss some of the challenges in their operating environment which have been considered in the development of their Strategic Plan. 'Transformative technology' is one such megatrend identified and highlights advances of digital, genetic, material sciences that are impacting food production and transport and sophisticated tools such as remote sensing and genetic technology that improves pest and climate resistance.

In Hort Innovation's latest Annual Report[22] the list of new R&D investment projects highlights the relevance of genomics, precision agriculture solutions, surveillance, supply chain collection data, diagnostics and next generation sequencing, AgTech and remote sensing for biosecurity surveillance. One specific highlight of Hort Innovation's 2018-19 year was the delivery of the project Remote Sensing for Biosecurity Surveillance in Urban and Peri-Urban Environments, which mapped biosecurity threat areas. Hort Innovation also state their future aim of investing and delivering new technology relating to crop monitoring tools and pollination in protected areas.

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[21] Horticulture Innovation Australia Limited (2019), Strategy 2019-2023, Growing into the future
[22] Hort Innovation (2019), Annual Report 2018-29

B-10. Meat and Livestock Australia and Red Meat Advisory Council

Specific priorities

End-to-end traceability
Digital supply chain
Animal identification
Data capture and analytics
AI
Automation
Communication tools
Measurement technology
DEXA scanning

Meat and Livestock Australia (MLA) have an overarching goal to deliver transformational change for industry and to drive producer profitability, sustainability and international competitiveness[23]. This mission is supported by MLA's strategic focus area of 'decisions informed through data and insights' (e.g. data capture and sophisticated analytics) and MLA plan to explore platforms and tools that improve access to supply chain data, stakeholder confidence, skills and decision making processes.

MLA's 'Our livestock' focus area explores the need for innovative production systems and traceability technology to enhance productivity, animal health, welfare, biosecurity and sustainability. Within MLA's 'Our systems' focus area, data sharing in a whole-of-supply chain data bank, traceability and quality assurance systems is highlighted to improve decision making, productivity, profitability and consumer trust. MLA also highlight some of the technological factors currently influencing the sector including disruptive automation, measurement technologies, carcass measurement, assurance systems and mobile and online communication tools.

MLA's 2018-19 Annual Report highlights some specific technology that has recently been introduced including the LEAP V automation, DEXA and MEXA carcass scanning technology, virtual reality, feedlot technology, digital value chain and the electronic traceability system, among others. Looking forward, the MLA's Annual Investment Plan (2020-21) reiterates some of the MLA's focus areas including objective measurement, integrity systems and digital value chain information.

RMAC's Red Meat 2030[24] reinforces some of the MLA's focus areas and includes the principles of 'building trust and respect through the supply chain' and 'supporting innovation and early adoption of technology'. The principles discuss RMAC's focus on enhancing end-to-end traceability, supply chain integration, digital connectivity and automation. RMAC also promote their focus on creating a user-centric supply chain system, data standards and capture processes, automated connection and data sharing, full supply chain digital coverage, artificial intelligence and real time traceability systems.

B-11. Sugar Research Australia

Specific priorities

Precision agriculture
Plant genetics and diagnostics
Forecasting
Processing technology
Sensors
Automation

Sugar Research Australia's (SRA) Strategic Plan[25] contains eight focus areas with an overall aim of improving members' and other stakeholders' on-farm productivity. Some of the SRA's focus areas that have potential technological applications include variety development, soil health and nutrient management, milling efficiency technology, technology transfer and adoption. These focus areas are complemented by the SRA's goals to drive profitability through innovation-led productivity gains and to enhance capability through knowledge transfer and adoption.

Under the SRA's eight focus areas, specific RD&A focus areas have been identified to meet industry and stakeholder priorities. SRA's priority of 'optimally-adapted varieties' highlights their focus on plant genetics and diagnostic technology for genetic screening while the 'soil health' priority focuses on climate variability and forecasting capabilities.

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[23] Meat and Livestock Australia (2020), Strategic Plan 2025
[24] Red Meat Advisory Council (2020), Red Meat 2030
[25] Sugar Research Australia (2017), SRA Strategic Plan 2017/18 – 2021/22

The 'pest and disease' focus area highlights the importance of disease and weed management technology. Other focus areas highlight precision agriculture, harvesting, mill processing and energy efficiency technologies.

The SRA also released a National RD&E Strategy[26] for industry in 2017, which sets out four RD&E themes including products, productivity, stewardship and people. Specific to the theme of 'products', SRA note research potential in agronomic packages (e.g. GPS and sensors), extraction and harvesting technology, the 'productivity' theme identifies the challenge of overcoming technology adoption such as harvesting technology and the 'stewardship' theme identifies potential in data technologies, traceability, measurement and forecasting technologies.

The SRA's Plan also identifies the various scientific and technological disruptors to the Australian sugarcane operating environment. These include big data, sensors, robotics, automation, drones, sensors, GPS, biotechnology and genomics.

B-12. Wine Australia - Australian Grape and Wine Authority

Specific priorities

Traceability
Blockchain
Climate change mitigation
Robotics
Remote sensing
Machine learning
Big data management
Digital engagement

Wine Australia's Strategic Plan[27] (2020-25) consists of five key strategies relating to marketing, integrity, fostering excellence, sustainability and business sustainability. These strategies feed into the industry's vision to achieve sustained value growth, drive an innovative culture, increase participation and increase diversity and excellence.

To ensure that these strategies are delivered, Wine Australian has complied a series of KPIs to measure their effectiveness, efficiency and transparency relating to their activities and investments. With a focus on the technology, Wine Australia will assess themselves as to how well they can foster new traceability technologies such as blockchain, AgTech innovations to improve quality, efficiency and sustainability and climate change mitigation and adaptation technologies and tools.

In Wine Australia's 'Enhance grape and wine excellence' strategy, there is a focus on realising the benefits of AgTech, robotics, machine learning and big data management. Secondly, in their 'Grow sustainable environments' strategy, there is a focus on attracting innovative technology developers to address the wine sector's issues with addressing carbon emissions and goal to become carbon neutral by 2050. Thirdly, Wine Australia are encouraging the use of targeted information and data driven decision making to enhance industry's decision-making processes.

Aligning to Wine Australia's focus on driving decision making with data and the use of robotics and sensors, Wine Australia (in collaboration with the University of Adelaide) delivered a digital platform called VitiVisitor to growers in South Australia. The platform allows growers to analyse large volumes of data to assess vineyard performance, coordinate advice on vineyard management while increasing collaboration among viticulture growers, researchers and engineers focusing on remote sensing, farm economics, water accounting, artificial intelligence, machine learning and robotics technology (WIne Australia, 2020)[28].

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[26] Sugar Research Australia (2017), National Sugarcane Industry RD&E Strategy
[27] Wine Australia (2020), Strategic Plan 2020-25
[28] Wine Australia, Technology to transform vineyard management, January 2020

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Department of Industry, Science, Energy and Resources

Business
Cooperative Research
Centres Program

SmartSat CRC Head Office:
Lot Fourteen, Level 3, McEwin Building
North Terrace, Adelaide, SA

info@smartsatcrc.com
smartsatcrc.com